

Age, sex, and temporary resident originated prescribing units (ASTRO-PU): new weightings for analysing prescribing of general practices in England

Sarah J Roberts, Conrad M Harris

Abstract

Objective—To derive demographic weightings to replace the existing system of prescribing units used in analysing prescribing by general practitioners in England.

Design—The prescribing data for one year from a sample of 90 practices in 80 family health service authority areas were used to calculate the relative frequency with which items were prescribed, for each sex, in nine age bands and for temporary residents. Data on the variation in cost per item by age and sex then allowed estimates to be made of the relative costs for these groups. Integer values for both the item based and cost based weightings were obtained by conversion to optimal integer scales.

Main outcome measures—Item based and cost based weightings for each of the 18 age-sex groups and for temporary residents. The cost based weightings were considered more appropriate to the context in which the new system was to be used.

Results—Prescribing costs increased noticeably, for both sexes, in the middle years (ages 35-64). Compared with the existing system, the cost based weightings (ASTRO-PU) gave greater weight to patients aged 45 and over, especially those in the 55-64 age band, at the expense of younger patients. Children under 5 received twice as many items as those aged 5-14, but the inexpensiveness of their drugs made the cost based weightings of the two groups equal. Similarly, women were generally given more items than men, but at a lower average cost per item, which reduced differences between the sexes in the cost based weightings. Costs for patients aged 75 and over, compared with those aged 65-74, were higher only for women.

Conclusions—The cost based weightings proposed are believed to reflect the present distribution of prescribing costs, in relation to age and sex, in English general practice. They are intended for use in analyses at practice level.

Introduction

General practitioners have been receiving reports containing data about their prescribing since the early years of the NHS, and these have always included comparisons with local and national averages. In an attempt to make the comparisons more valid, a weighting factor was introduced in about 1983 that took account of the greater need of elderly patients for medication. Each patient aged under 65 was counted as one prescribing unit, while patients of 65 and over counted as three. The system seems to have been based on the relative numbers of items dispensed for the two age groups.

This weighting was not widely understood by general practitioners until prescribing analysis and cost (PACT) reports appeared in 1988. Before then it was of interest mainly to the regional medical officers who visited those doctors whose drugs costs were more than 25% above their local average.

Comparisons of practices' prescribing figures with those of their family health service authorities became more overtly important in 1990, when these authorities took on a managerial role, appointed medical advisers to monitor practices' prescribing, and set indicative prescribing amounts and prescribing budgets. Regional health authorities, newly responsible for allocating the prescribing budgets of their family health service authorities, found a need for formulas that would help them disburse the money equitably. Weighting therefore became a matter of greater importance than it had been hitherto.

Many factors affect the level of a population's drug consumption,¹ but its demographic structure is undoubtedly one of the most influential. Any weighting system should therefore include, as one component, good age and sex weightings. The purpose of the present study was to derive weightings that would be more accurate than those of the existing system.

The prescribing rates for different patient groups may be expected to reflect their consultation rates. These rates are known to vary with both age and sex,² so that these two variables should be included in a model for demographic weighting.

The number of patients with temporary registration varies from practice to practice, and in some areas it is high enough to have an important effect on prescribing. At present the additional items and costs are concealed within an adjusted list size, and this has been a source of confusion in the reports sent to practices that a weighting for temporary residents will put right.

It seems appropriate for several reasons that a system weighting for demographic factors should move from being based on the relative number of items prescribed for different groups to one based on the relative cost of the items. Not only may the weightings be used in setting budgets but also the number of items given to a patient over a year may be a poor indicator of the amount of medication prescribed, and the costs of the drugs commonly given to different demographic groups vary considerably.

The need for valid and acceptable demographic weightings for use in analysing general practitioners' prescribing is likely to endure, though the values may call for adjustment from time to time. In this paper we describe how we derived a new set using the best data available. Because they were age, sex, and temporary resident originated we called these prescribing units ASTRO-PU.

Prescribing Research Unit,
Academic Unit of General
Practice, University of
Leeds, Leeds LS2 9NZ
Sarah J Roberts, *senior
statistical officer**
Conrad M Harris, *director*

Correspondence to:
Professor Harris.

*Now lecturer in medical
statistics, Wolfson Unit of
Clinical Pharmacology,
University of Newcastle upon
Tyne.

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Methods

AGE-SEX SPECIFIC PRESCRIBING DATA

Because no detailed data were readily accessible for modelling cost based relative prescribing rates directly, an indirect procedure was adopted. This involved derivation of item based, within practice, relative prescribing rates, followed by conversion to a cost basis using age-sex related estimates of cost per item obtained from pooled practices. The raw weightings obtained were then converted to an integer scale for ease of use.

For deriving item based weightings, data were obtained from the VAMP research data bank for 90 practices with list sizes in excess of 1500 registered patients, for the year ending 31 March 1991. For each practice the number of items prescribed during the year and the number of patients were detailed by registration status and sex and in each of 10 age bands (0-4, 5-14, subsequent 10 year bands to 75-84, and 85 or over). The numbers of registered patients were as at 31 March 1991; the numbers of temporary residents included all those not permanently registered with the practice who consulted during the year and as such represented a count of events rather than a measure of patient years at risk. Temporary residents were classified by sex only, age banding being impractical because of the small numbers involved. Prescribing data related to items ordered, though some of these might never have been dispensed.

ITEM BASED WEIGHTINGS

Estimates of the relative item based prescribing rates for the groups were derived from a log linear model for the number of items prescribed, assuming mean rates proportional to the number of patients in each group. Three factors were included in the model: age, with 11 levels (including temporary residents as the additional level); sex, with two levels; and practice, with 90 levels. Theoretically, 1980 observations were available, but in some categories—particularly those relating to temporary residents and men over 85—there were few or no patients. Only the 1904 observations relating to patient populations of 10 or more were included. Analysis was carried out using GLIM,³ and the techniques outlined by Breslow⁴ were used to accommodate the extra-Poisson residual variation found.

All three factors contributed significantly to the model, as did the two way interaction between age and sex. The other interactions, practice by age and practice by sex, added little in terms of improving the model's fit. As the age-sex interaction terms were required the model was redefined with all age-sex combinations as a single demographic factor, giving the advantage of more readily interpretable parameter estimates.

The age bands 85 and over and temporary resident had smaller patient populations and more excluded observations, leading to parameter estimates with higher standard errors for these groups. Consequently, the model was refitted with the data for men aged 75-84 combined with that for men aged 85 and over, and a similar modification for women; and the two temporary resident groups were also combined. This reduced model, with 19 age-sex groups, was based on 1688 observations. The demographic parameter estimates indicate the relative prescribing rates within practices for the various age-sex groups and provide a basis for item based patient weightings. The 89 parameter estimates defined by the practice factor in the model reflect the differences between individual practices in their absolute levels of prescribing.

COST PER ITEM RATES

To convert from item based to cost based relative

prescribing rates additional data on cost per item were required. These were made available from a study by Edwards *et al* which was conducted in two large health centres (eight practices), covering 15 000 items dispensed to a population of around 45 000 patients.⁵ The study gave information both on the relative cost of items by age and sex and on the distribution of items across the major drug groups according to patients' ages. In addition, cost per item data for England, based on the year ended 31 March 1991, were made available by the Prescription Pricing Authority. The average net ingredient costs at 1991 prices for the major drug groups were: gastrointestinal £10.08; cardiovascular £7.27; respiratory £6.90; central nervous system £3.14; infections £4.07; musculoskeletal £9.30. Across all other therapeutic groups the corresponding cost was £5.89, giving an overall average of £6.07.

The average cost per item for each demographic group was initially estimated by taking the population weighted combination of the values found in the two health centres studied by Edwards *et al*. In addition, their percentage distribution of items across drug groups, by patient age (fig 1), was applied to the Prescription Pricing Authority data to arrive at a less refined scale of relative cost per item, which confirmed the trend of Edwards and colleagues' findings on the relation between item cost and age. A moderated scale of relative cost per item by both age and sex was then obtained by smoothing the initial estimates in conjunction with the latter scale. For temporary residents (all ages and both sexes) the average cost per item was used.

COST BASED WEIGHTINGS

Estimates of relative prescribing rates in terms of cost were calculated as the product of the item based rates and the cost per item rates. These were obtained for each of the 18 age-sex groups and for temporary residents.

INTEGER SCALES

To create a set of patient weightings appropriate for practical use the estimated rates were converted to a discrete scale of integer values. The conversion to an integer scale was undertaken with no prior reduction in

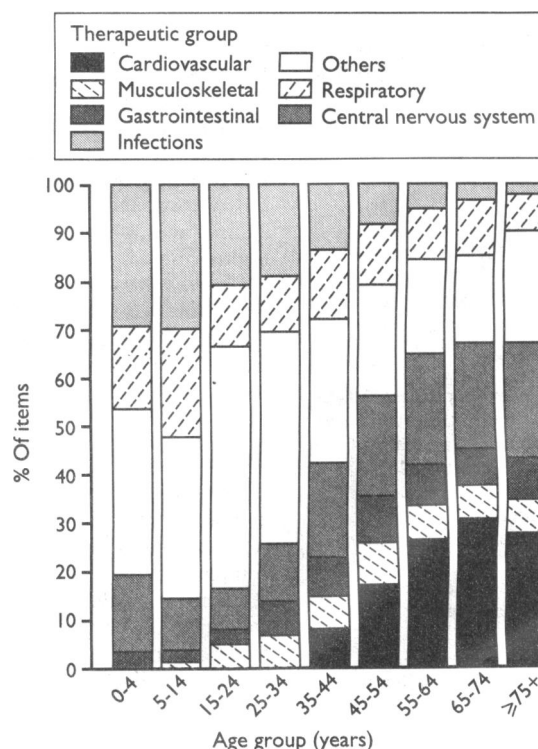


FIG 1—Distribution of prescribed items across therapeutic groups by age (derived from Edwards *et al*)

the number of demographic groups, although some groups would almost certainly be allocated the same scale values in the process. This allowed the maximal amount of differentiation to be retained. We also decided to assign a value of 1 to the age-sex group with the lowest rate and to allow a fractional value for temporary residents.

An optimal scale of cost based patient weightings (ASTRO-PU) was obtained by using a least squares procedure to fit integer values to the estimates of relative prescribing rates for the groups, subject to the constraints already outlined. For comparison a similar scale for item based rates was also produced.

Results

ITEM BASED WEIGHTINGS

Table I gives parameter estimates and corresponding 95% confidence intervals for the relative item based prescribing rates, with the groups "males 0-4" standardised to 1. All estimates relate to the reduced

TABLE I—Estimates of item based relative prescribing rates (95% confidence intervals) for age-sex patient groups

Age (years)	Male	Female
0-4	1.0	0.91 (0.85 to 0.96)
5-14	0.58 (0.55 to 0.62)	0.57 (0.54 to 0.60)
15-24	0.45 (0.43 to 0.48)	0.84 (0.79 to 0.89)
25-34	0.44 (0.41 to 0.46)	0.95 (0.90 to 1.01)
35-44	0.59 (0.55 to 0.62)	1.03 (0.97 to 1.10)
45-54	0.91 (0.86 to 0.97)	1.55 (1.46 to 1.64)
55-64	1.82 (1.72 to 1.93)	2.43 (2.29 to 2.58)
65-74	3.18 (3.00 to 3.37)	3.70 (3.49 to 3.92)
≥ 75	3.46 (3.27 to 3.67)	5.10 (4.81 to 5.41)
Temporary residents (all ages)	0.26 (0.24 to 0.28)	

TABLE II—Relative cost per item rates by patients' age and sex

Age (years)	Male	Female
0-4	1.0	1.0
5-14	1.75	1.75
15-24	2.85	2.15
25-34	3.00	2.15
35-44	3.25	2.70
45-54	3.25	2.75
55-64	3.15	2.50
65-74	2.05	2.50
≥ 75	2.70	2.25
Temporary residents (all ages)	2.50	

TABLE III—Cost based prescribing rates by patients' age and sex

Age (years)	Male	Female
0-4	1.0	0.91
5-14	1.02	1.0
15-24	1.28	1.81
25-34	1.32	2.05
35-44	1.89	2.78
45-54	2.96	4.06
55-64	5.74	6.08
65-74	9.54	9.38
≥ 75	9.34	11.48
Temporary residents (all ages)	0.56	

TABLE IV—Integer scales for cost based prescribing rates

ASTRO-PU*		
Age (years)	Male	Female
0-4	1 (1.05)	1 (0.95)
5-14	1 (1.06)	1 (1.04)
15-24	1 (1.34)	2 (1.89)
25-34	1 (1.38)	2 (2.14)
35-44	2 (1.97)	3 (2.91)
45-54	3 (3.10)	4 (4.25)
55-64	6 (6.01)	6 (6.36)
65-74	10 (9.99)	10 (9.82)
≥ 75	10 (9.78)	12 (12.02)
Temporary residents (all ages)	0.5 (0.54)	

*Integer weightings with, in parentheses, the cost based relative prescribing rates (table III) after scaling using optimal scale unit of 0.955.

model with only 19 groups, but the estimates initially obtained in the fuller model are highly concordant for the directly comparable age-sex groups, for temporary residents (both sexes), and also for individual practice effects. The initial model with 22 groups gave estimated rates of 5.01 and 5.45 for females aged 75-84 and 85 and over, as compared with the combined estimate of 5.10 for those aged 75 and over. For males the corresponding values were 4.36 and 0.23, identifying an extremely low prescribing rate for males of 85 and over.

Males had lower rates than females except in the two youngest age groups and the pattern of increase with age differed in the two sexes. In males there was little change from childhood until the rate rose, with sudden onset, from 45-54 onwards. In females the rate increased gradually from age 15-24 and then more sharply beyond the 45-54 age group.

The 89 parameter estimates relating to the practice factor varied threefold, from 0.67 to 2.08, giving an indication of the variation between practices in their absolute rates of prescribing. The 95% confidence limits of individual practice estimates were obtained as roughly 88% and 114% of the estimated values.

COST PER ITEM RATES

Table II shows the moderated scale of relative cost per item for the 19 groups with the rate for "males 0-4" again standardised to 1. (These relative costs can be translated to net ingredient costs in pounds at 1990-1 prices by multiplying them by 2.4.) In all save the two youngest age groups males had higher cost per item rates than females; for both sexes the values increased from childhood until the 45-54 age group, then showed a gentle decline.

COST BASED WEIGHTINGS

Table III shows the relative cost based prescribing rates. The lower costs per item for females largely redressed the imbalances due to their higher item rates.

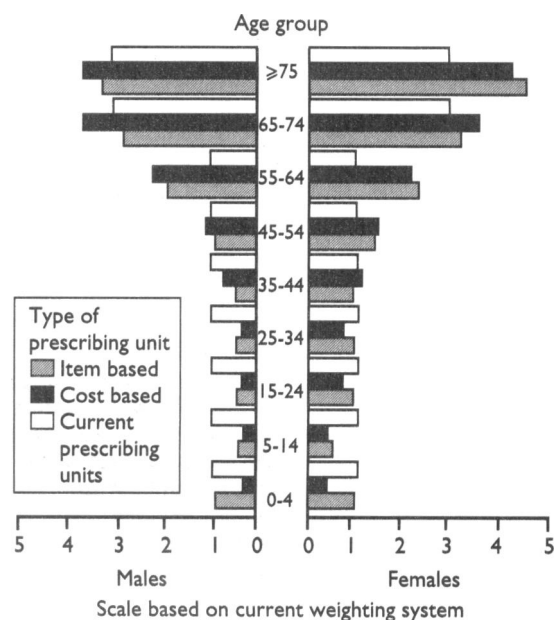


FIG 2—Comparison of current weighting system with derived item based system and cost based (ASTRO-PU) system

In a similar way the difference between children under 5 (low item cost, high item rate) and those aged 5-14 was also eliminated. For females the cost rate rose less steeply than for males, but starting earlier with the age group 15-24 as against 34-44 in males. Rates for males and females increased threefold and fourfold respectively by ages 45-54. At age 55-64 the rate for males virtually caught up with that for females, and for patients aged 65-74 the rates remained comparable. For those aged 75 or over the higher item rate for females was not entirely compensated for by lower item cost, leading to a further increase in the cost based prescribing rate, whereas for males the rate remained similar to that for the 65-74 age group.

INTEGER SCALES

The optimal conversion of relative prescribing rates to integer scales was achieved by taking scale units of 0.955 for costs and 0.505 for items. Table IV shows the cost based rates from table III after this scaling alongside the consequent integer scale derived (ASTRO-PU). On this cost based scale temporary residents can conveniently be allocated a value of 0.5.

COMPARISON OF ASTRO-PU AND CURRENT PRESCRIBING UNITS

Figure 2 illustrates how the integer scales derived here compare with the current system, which uses values of 1 and 3 only. By taking population age and sex data from 7513 practices (43 million patients) in England the total number of units was calculated for the current system, the item based scale, and the cost based scale. Standardisation of each scale of units by the corresponding national total then gave the directly comparable profiles shown in the figure.

For males under 45 and females under 35 both the cost based and item based scales gave a lower relative weight than under the current system; older age groups had higher relative weights under the scales derived here, with the greatest discrepancies occurring for the 55-64 group (both sexes) and for females aged 75 and over.

Discussion

The current system of prescribing units has many deficiencies and the scales derived here give a more comprehensive picture of the substantial variation in prescribing rates according to the patients' age and sex.

These are based on 1990-1 data and therefore also take into account the trends in prescribing over the years since the prescribing unit was first introduced in 1983.

The values were derived from prescribed rather than dispensed items, but there is no published evidence of any significant age based differential failure to present prescriptions for dispensing. It may indeed be argued that prescribing data are more appropriate than dispensing data should the weightings be used in circumstances relating to practitioners' perceptions of the need for medication. However, in comparing drug usage rates the effects of non-presentation need to be borne in mind.

The unavailability of prescription cost information for the sample practices necessitated a two stage procedure for obtaining the cost based units. This allowed adjustment for the evident variation between practices in their absolute item based prescribing rates but assumed cost per item rates based on pooled practice data. A uniform item cost with patient age and sex would lead to cost based prescribing rates identical with those based on items. Despite the substantial variation in the item costs used here, the resulting cost based ASTRO-PU's are still fairly close to the item based weightings for the majority of age-sex groups (fig 2). This is reassuring, given the narrower base from which cost per item rates were derived.

Another potential concern is that, although the patients in the 90 sample practices reasonably represent the national population in terms of age, sex, and social characteristics, the practitioners included in this sample may not necessarily be representative of general practitioners nationally. The designated model, however, specifically allows for an individual practice factor, and extension of our findings to other practices depends only on the assumption that relative prescribing rates within practices, by age and sex, are the same for all practices. The lack of any significant interaction effects between the practice and demographic factors in the model gave validity to this assumption.

The age-sex variation in prescribing rates found in this study was similar to that found by Edwards *et al* and also to that of a later study in one practice.^{5,6} A higher item based rate, but cheaper items, for females over 15 in comparison with males of a corresponding age is indicated in all three studies, as is a steep increase in prescribing for patients between ages 45 and 65. No difference in the cost of prescribing for "young" (65-74) and "old" (75 and over) elderly patients is evident for men, though the cost for women of 75 and over is somewhat higher. Age-sex prescribing rates calculated from published Intercontinental Medical Statistics data confirm a similar pattern of relative rates.⁷

A phenomenon of extremely low prescribing rates for men of 85 and over was noted also by Edwards *et al*,^{5,6} and this remains, as yet, unexplained. Bearing in mind the small numbers of patients in this age-sex group, use

of the combined value for the 75 and over groups has little impact on ASTRO-PU's at practice level and avoids possible controversy over spectacularly differing weights for apparently close patient groups.

The individual estimates for the practice factor in the model indicate a substantial variation between the sample practices in their absolute levels of prescribing. Many different influences may be contributing to this variation, including local morbidity and social characteristics as well as individuality of practices and practitioners. However, the threefold range is considerably less than the range across patient age-sex groups, and patient demography is clearly a major contributory factor to variation in general practitioners' prescribing rates.

List inflation affects the value of any weighting system, but not enough is known about it at practice level for us to tell how its effects on the new and the existing systems will differ.

The consequences to any individual practice of the new weightings will depend on the age-sex structure of its patient population. Nationally, about a tenth of practices have a ratio of ASTRO-PU's to prescribing units greater than 110% of the national ratio, and a similar proportion fall below 90% of the national ratio. Practices with fewer than 1500 patients are disproportionately represented in these extremes.

Finally, we wish to emphasise two points. Firstly, many factors other than the age and sex structure of a practice population influence prescribing patterns and costs. Our weightings account for only about 25% of the variation in costs between practices. Secondly, these prescribing units are intended for use at practice level; in comparisons at family health service authority or regional health authority levels they give results very little different from those that use the existing system.

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- 1 Department of Health. *Improving prescribing*. London: Department of Health, 1990.
- 2 Royal College of General Practitioners, Office of Population Censuses and Surveys, Department of Health and Social Security. *Morbidity statistics from general practice 1981-82. Third national study*. London: HMSO, 1986.
- 3 GLIM: *Generalised linear interactive modelling*. London: Royal Statistical Society, 1986.
- 4 Breslow NE. Extra-Poisson variation in log-linear models. *Applied Statistics* 1984;33:38-44.
- 5 Edwards C, Metcalfe D, Burn A, Watson K, Seward FCN, Jephson MH, *et al*. Influence of patient age on drug costs: an investigation to validate the prescribing unit. *International Journal of Pharmacy Practice* 1991;1:73-8.
- 6 Edwards C, Purves I. The prescribing unit: is it really that accurate? *Prescriber* 1992;9:103-6.
- 7 Mann RD, Rawlins MD, Fletcher P, Wood SM. Age and the spontaneous reporting of adverse reactions in the United Kingdom. *Pharmacoepidemiology and Drug Safety* 1992;1:19-23.

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